Feb. 14, 1933. N. GERTEN ET AL 1,897,373

WAVE ANTENNA

Filed July 29, 1930 3 Sheets-Sheet 1

Fig. 1,

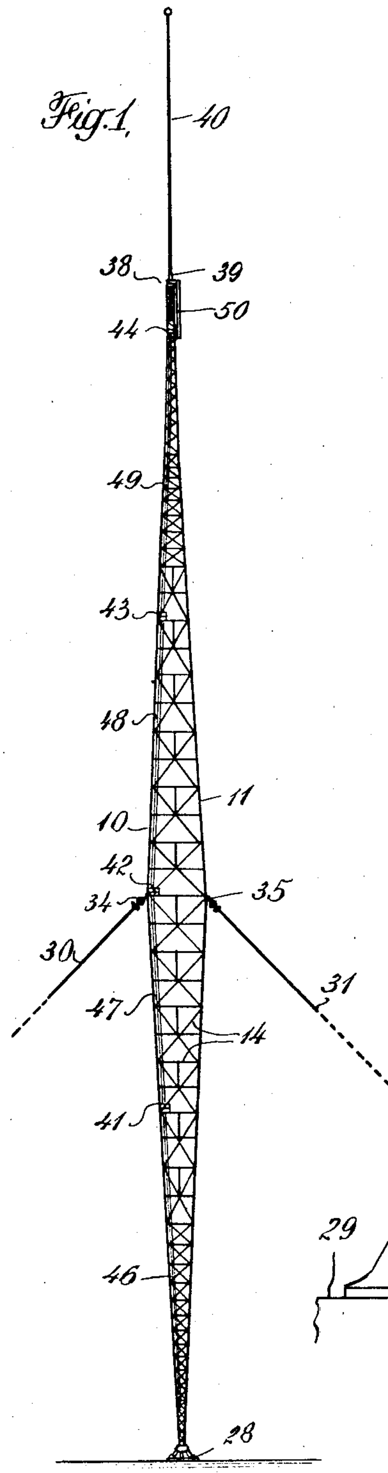

Fig. 2,

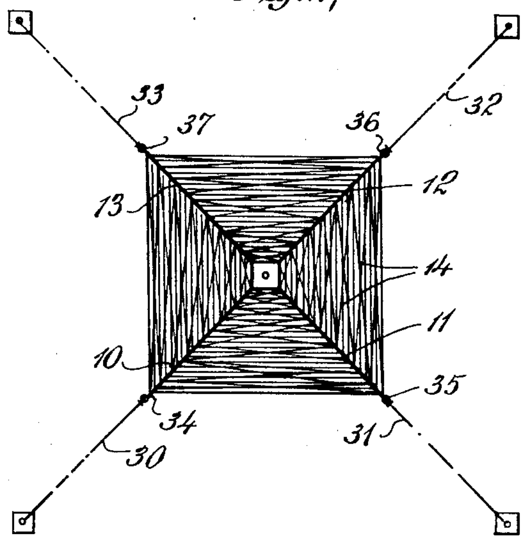

Fig. 3,

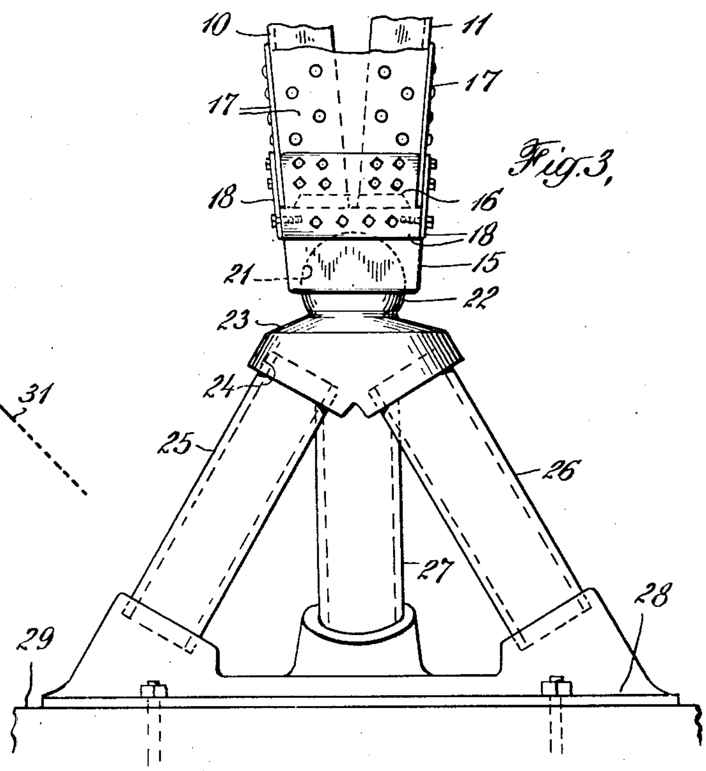

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Fig. 4,

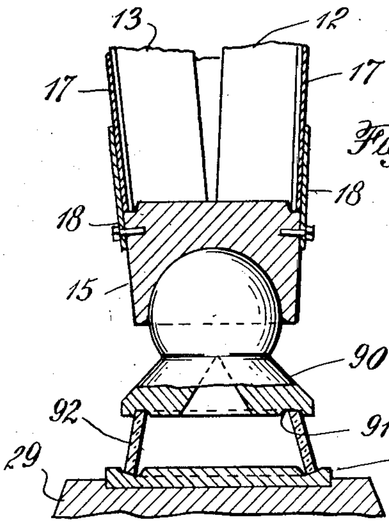

Fig. 7,

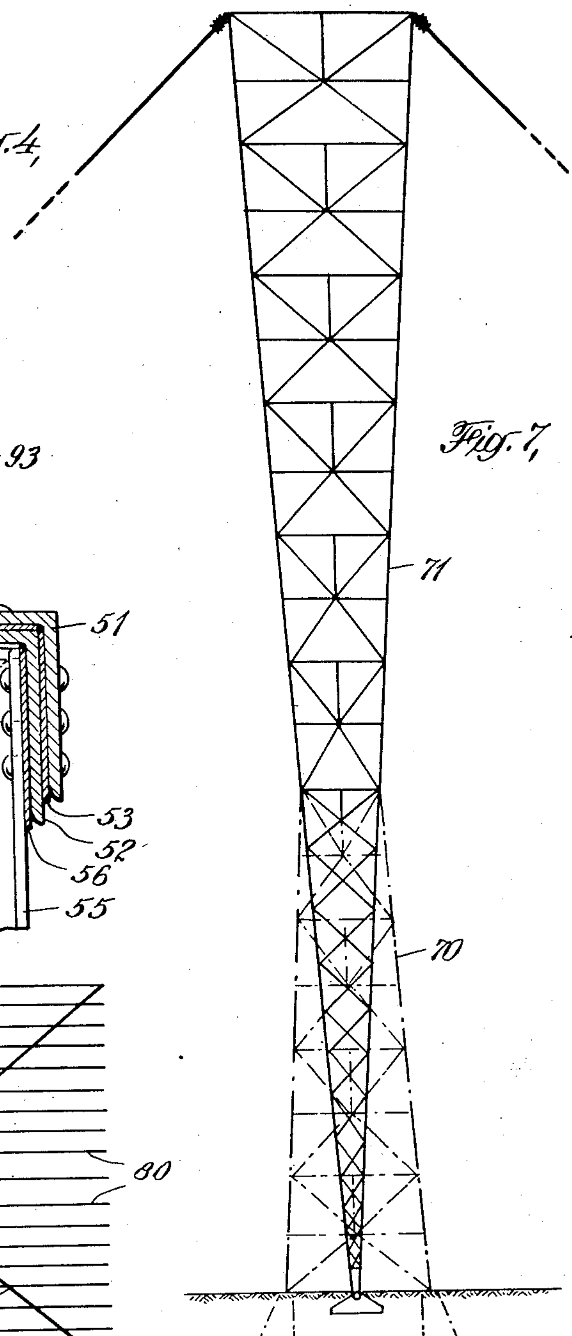

Fig. 5,

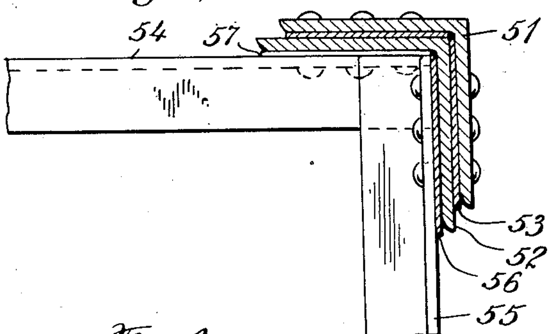

Fig. 8,

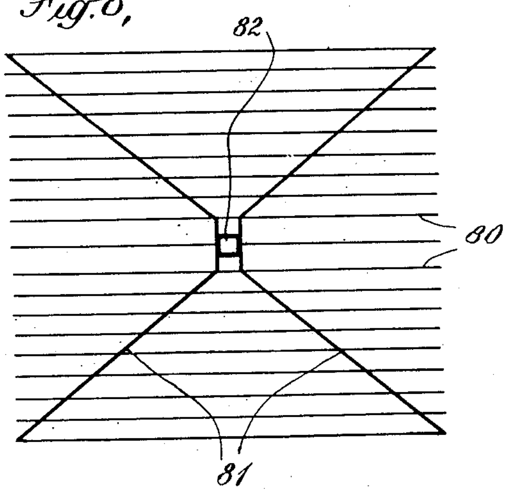

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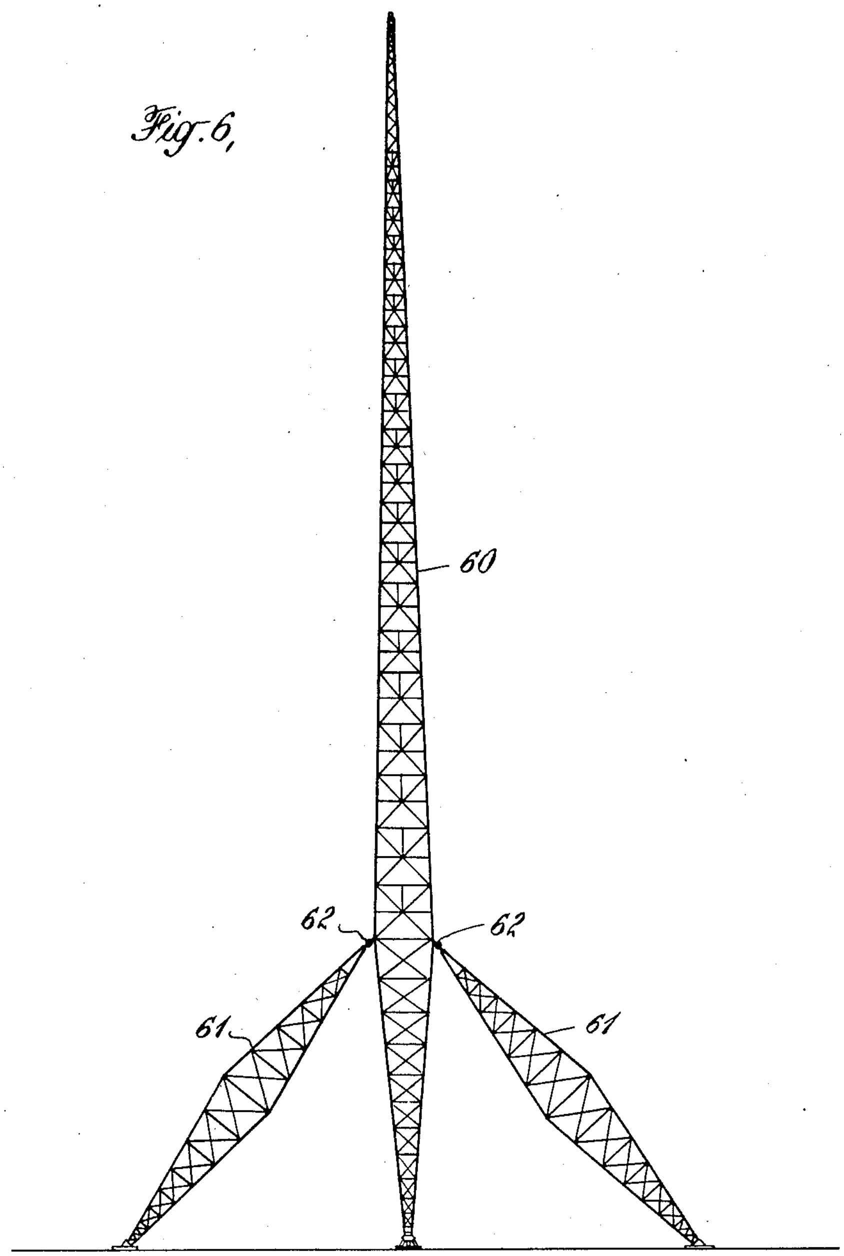
Fig. 6,



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UNITED STATES PATENT OFFICE

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WAVE ANTENNA

Application filed July 29, 1930. Serial No. 471,466.

This invention relates to wave antennæ and more particularly to vertical conductors adapted to radiate radio signals.

The principal object of the invention is to improve the transmission of radio signals.

A related object is to obtain improved means for radiating electromagnetic waves.

A further object is to provide an antenna of the vertical conductor type and a method of erecting the same.

In the art of radio transmission it has long been recognized that an antenna consisting of a single vertical conductor is most desirable for certain purposes, particularly radio broadcasting. The principal advantage of the vertical type antenna over other types is that it radiates wave energy equally in all directions. The chief difficulty heretofore encountered in the use of this type of antenna has been to suitably support the antenna conductor. There are many mechanical and electrical difficulties inherent in such supports which in the past have not been satisfactorily overcome. The length of a vertical antenna should be about a half wave length, so the height required for use at the usual broadcast frequencies is several hundred feet, thereby necessitating a large supporting structure composed of metal of great strength, and steadied by many guy wires. When such a structure is used to support the antenna conductor, the effect of the supporting metal in close proximity to the antenna is to absorb a considerable amount of the radiated energy, especially since there are present a multitude of leakage paths to ground along the guy wires.

The foregoing difficulties are obviated in accordance with the present invention by the provision of a mast or tower, which itself acts as the radiating antenna. The mast is insulated from the ground at its base and is securely maintained in its vertical position by a relatively small number of supports from which the mast is also insulated. The antenna mast, or tower, is composed of uprights interconnected by struts in such a manner that the assembly constitutes a permanent, rigid structure of great height and comparatively small girth, or waist. Preferably, the structural members are composed of lengths of structural steel which are firmly bolted or riveted together. At any horizontal cross-section the uprights forming the skeleton of the antenna constitute the corners of a polygon. In the preferred form, the polygonal cross-section tapers from its largest area at a portion of the antenna intermediate the ends, which portion will be called the waist, to a very small area at the base; the cross-section preferably tapers also above the waist to succeedingly smaller areas. The base, which is electrically insulated from ground rests on a supporting member which is virtually a point support.

A feature of the invention is the attachment of a relatively small number of secondary supports at points at, or near the waist, these points of attachment lying in substantially a single horizontal plane. Insulators are associated with the secondary supports to insulate the antenna from ground. The antenna tower, then, constitutes a beam having two places of support, one the base end and the other the plane of the secondary support attachments; hence, it can be called a rigid, or inarticulate, cantilever antenna, and the methods of design and computation of stresses employed with ordinary cantilever beams are equally as applicable in the case of this antenna; so the procedure in the design of the present antenna is much simpler than in the case of previously used antenna supporting towers in which broad bases and a multitude of guy wires attached at various points are employed. Furthermore, due to the small insulated base and the small number of insulated secondary supports, which may be guy wires, the amount of energy leakage to ground is very small.

In one embodiment there are employed in place of guy wires, rigid, beam-like supports which are preferably built of structural steel after the fashion of the tower itself. An advantage of this type of support is that the entire structure in general is in compression, whereas guy wires are in tension.

Another feature of the invention is the manner of connecting together the various structural members so that a continuously good electrical conductor is obtained. Since the tower itself acts as the antenna, it must be in effect a single electrical conductor of low resistivity from base to top. If the usual method of joining the structural members were employed, there would be many high resistance joints due to corrosion and imperfect contact between the members. Accordingly, it is contemplated to insure high and uniform electrical conductivity throughout the cantilever antenna by placing between the jointed surfaces, sheets of soft, highly conducting material which will flow under the pressure of riveting or bolting.

Another feature is the method of erection, which is in itself a serious problem in the building of tall, unstable towers. To obviate the necessity of building a separate supporting structure, it is contemplated to assemble a stable section which will ultimately be an upper section of the antenna. Then, using this ultimate upper section as a scaffolding, the unstable base section is erected and fixed in position.

Another feature is a means for adjusting the effective length of the antenna. This adjustment is provided by a conducting rod, or pole, which extends vertically above the tower itself, making electrical contact therewith, the pole being movable upward and downward through the top of the tower. This feature is of considerable importance since it is difficult to accurately predetermine the optimum length of the antenna for a given signal wave.

Other features of the invention relate to means for mounting the antenna, for making inspections and adjustments.

The foregoing and other features of the invention will be more clearly understood from the following detailed description and the accompanying drawings, of which:

Figures 1 and 2 illustrate an elevation and a plan view respectively, of a vertical type antenna embodying the invention;

Figure 3 shows the details of the construction and mounting of the base of the mast of Figures 1 and 2;

Figure 4 illustrates an alternative base arrangement;

Figure 5 is a detailed view of the system used in joining the structural members to obtain high electrical conductivity throughout the antenna;

Figure 6 illustrates another form of antenna embodying the invention, in which the secondary supports are rigid members;

Figure 7 illustrates a scheme for erecting the tower, utilizing an upper portion of the tower as a scaffolding for the lower portion;

Figure 8 illustrates a grounding system suitable for use in conjunction with the antenna of this invention.

The vertical antenna shown in the elevation and plan views of Figures 1 and 2, respectively, comprises four uprights, 10, 11, 12 and 13, composed of lengths of steel angle girders. The uprights are interconnected by structural members 14 to provide the necessary rigidity and strength. As viewed from the top, the uprights are arranged at the corners of a square, as shown in Figure 2. The cross-section of this square tapers from its largest area, which is at or near the middle of the tower, and which will be called the waist, to succeedingly smaller areas toward the base and toward the top. At the base, the uprights are brought together almost to a point. The horizontal area of the waist is made as small, relative to the height, as possible, consistent with adequate strength and rigidity; and the longitudinal extent of the waist is preferably made very small in comparison with the total height of the tower. It is found that the height can be made more than twenty times the breadth of the waist, i. e., the side of the widest cross-sectional square.

The construction of the base is more clearly understood from an inspection of Figure 3, which is a detailed view of the base of Figure 1. The lower ends of the four uprights are brought together and rested upon a heavy base plate 15 having a square, horizontal cross-section and provided with a square, raised portion 16 centrally located at the top, around the corners of which the lower ends of the four upright angle girders are placed. The lower ends of the girders are riveted or bolted together by four side plates 17 having the proper thickness to bring them flush with the square sides of the base plate 15. Four additional side plates 18 are bolted over the upper portion of base plate 15 and over the lower portion of side plates 17.

The base plate is provided with a recess 21 which sets over a ball 22 integral with the ball member 23. The underside of the ball member is provided with circular openings 24 which receive the ends of cylindrical insulators 25, 26 and 27. The opposite ends of the insulators are set into suitable recesses in a heavy foundation plate 28 which is preferably bolted to a concrete foundation 29.

Figure 4 illustrates in section an alternative form of base mounting in which only one insulator is required. The underside of the ball member 90, instead of having three receptacles for three cylindrical insulators, is provided with an annular groove 91 which fits over the end of a single heavy conical insulator 92, which, in turn, sets into a suitable groove in the foundation plate 93. Except for the insulator and the manner of mounting thereon, the construction shown in Figure 4 is identical to that shown in Figure 3. Since Figure 4 shows a vertical section through the center it brings out more clearly than Fig. 3 the construction of the base of the tower which rests on the ball.

In addition to the primary support at the base, which receives the major portion of the load, there are provided secondary supports at or near the waist of the tower to maintain the vertical position. These secondary supports take the form of guy wires 30, 31, 32 and 33, attached at the four corners of the tower and insulated therefrom by insulators 34, 35, 36 and 37, respectively, the guy wires having sufficient tension to stabilize the tower. The points of attachment of the guy wires are located in substantially a single horizontal plane, that is, perpendicular to the longitudinal axis of the tower. There is no special altitude at which the guy wires must be placed, but it is desirable that they be attached as low as possible, consistent with adequate strength and rigidity, in order that they will absorb as little of the radiant energy as possible. The waist will be found a convenient place of attachment.

The top of the tower, which tapers to a relatively small area, as compared with that of the waist, is provided with a platform 38, having a centrally located opening therethrough. Directly over this centrally located opening, there is built a supporting structure 39 for holding a staff, or pole 40. The supporting structure is provided with suitable means for enabling the pole to be raised or lowered relative to the platform in order that the effective height of the antenna may be adjusted. A suitable means for this purpose is a pair of collars axially aligned with the opening in the platform. The pole is inserted through the collars and is held at any desirable elevation by means of set screws in the collars.

To permit inspection of the antenna, and to make accessible the adjustable pole, there are provided a number of platforms 41, 42, 43 and 44, and ascending ladders 46, 47, 48, 49 and 50. The platforms are suitably fastened at various altitudes throughout the tower. The ladders, around which there are provided protecting cages, lead from each platform to the next.

The adjustable pole is not essential for good operation of the antenna but, rather, it is a refinement which may be omitted if desired.

Figure 5, which is a detailed view of one of the structural joints in the tower, illustrates a method of making the joints which insures good electrical contact between the structural members. Members 51 and 52 are lengths of angle girders included in one of the uprights. The ends of the angle girders are joined in a lap joint by bolts or rivets with a filler 53 between the overlapping faces of the girders. The filler is of a soft metal having high electrical conductivity, which flows under the pressure of bolting or riveting and fills all the uneven portions of the overlapped faces of the angle girders. Angle beams 54 and 55 are two of the cross-beams interconnecting the uprights; they are attached to the upright girders with sheets 56 and 57 of filler material between the overlapping faces.

It is not essential that high conductivity be insured by the use of the filler metal; if desired, the well-known bonding system could be employed instead.

Figure 6 illustrates a vertical type of antenna embodying the invention in which the secondary supports are rigid structures ordinarily in compression, instead of guy wires in tension. The antenna itself is a vertical tower 60 which may be somewhat similar to that of Figure 1. The secondary supports are beams 61 preferably of structural steel construction similar to that of the tower itself. The supporting beams are attached at the waist of the tower through insulators 62 and are anchored to the ground at their opposite ends. This construction provides a more suitable tower than the type illustrated in Figure 1, since all of the members are in compression, except for bending due to windage. Because of the greater strength of the rigid type of support, the supports may be attached lower on the tower than it is desirable to attach the guy wires of Figure 1; the lower the supporting members are attached, the smaller is the amount of radiated energy absorbed by them. The beam supports may be attached to the antenna at about one-quarter the distance from the base to the top. It is desirable that the waist, or broadest portion, of the antenna be situated at the points of secondary support.

If desired, the antenna may be made adjustable by placing a movable pole at the top of the tower in the manner of the pole arrangement of Figure 1.

Due to the fact that the antenna towers of this invention do not have broad bases, but instead have bases which are virtual points, there is difficulty attendant upon their erection. There must be provided some kind of supporting structure to enable the lower portion of the tower to be erected and permanently supported. According to the following method, the necessity for additional supporting structure is obviated. In accordance with this method, illustrated in Figure 7, one portion of the tower, which will ultimately become an upper portion, aids in the erection of the lower portion. An upper section 70 of the tower, shown in dotted lines in Figure 7 is first erected on the ground directly over the foundation for the base, the largest cross-section of this tower section being fixed to the ground. Then, utilizing this section as a scaffolding or supporting structure, the base section 71 of the tower is erected, and then guyed to maintain it in position. As soon as the base section is firmly fastened, section 70 is removed and the erection of the tower is continued upon the base section 71.

Since the only supporting places are the base and the plane of the secondary supports, the towers shown in Figures 1 and 6 are evidently cantilevers. The computation of the stresses on a cantilever are relatively simple and the methods of computation are found in any text dealing with the mechanics of beams; so the antennæ of this invention readily lend themselves to computation and are simple to design.

In using this type of antenna, an important problem is to provide a suitable ground connection for the radio apparatus. Good results are obtained by laying a network of wires in the ground beneath the antenna tower, bonding the network by suitable electrical connectors, and leading the bonds to a good water ground. Figure 8 illustrates a suitable grounding network. Electrical conducting wires 80 are laid in the ground parallel to each other, about two feet apart, and cover an area which is substantially a square having diagonals intersecting at the base of the antenna. Bonding wires 81 traverse the square substantially in the form of diagonals, and are electrically connected to each of the parallel wires. The bonding wires should be led to a suitable water or damp ground. The small square 82 represents the foundation of the antenna. A convenient manner of laying this ground network is to plow furrows in the ground and lay the wires in the furrows, after which the furrows may be filled in. The area covered by the network of wires does not have to be square, but may have almost any convenient shape, such as a circle. When a circular network is employed the network wires can extend radially from the base of the antenna, and the bonds may be circular. The diameter or the side of the circle or square, when these shapes are employed, should be about twice the height of the antenna.

The best operation is obtained when the length of the antenna is approximately a half-wave length. Accordingly, the height from the base plate to the top of the tower (or pole if there is one) should be made approximately equal to half the length of the wave. It has been found that the velocity of wave propagation in the antenna is practically the same as that of light or of an electro-magnetic wave. Hence, in computing the height of the tower the wave length, to a close approximation, may be taken equal to the length of the radiated wave. There are introduced, however, slight variations from this approximation dependent upon ground conditions. The adjustable pole, then, enables the optimum height to be readily obtained. This optimum height has, in some instances, been found to be slightly greater than a half wave length; for example, 58% of the wave length has been found to be an optimum height.

Because its girth, or waist, is small in comparison with the length of the wave, the structure effectively radiates waves as though it were a simple conductor of negligible thickness, the degree of wave interference due to the girth being negligible. Because of the small number of supports, the amount of leakage to ground and of energy lost in radiation to the supporting structure, is negligible.

The antenna lead of the radio apparatus may be connected at any point in the antenna, but preferably it should be connected to the base of the antenna in order that the same shall function as a half-wave antenna. If desired, however, the connection may be made at a point midway between the two ends of the tower, this latter connection resulting in a pair of quarter-wave antennæ which may operate as efficiently as a half-wave antenna. A disadvantage of the quarter-wave connection, though, is the difficulty of making a suitable connection between the apparatus and the midpoint of the tower.

It will be understood that the invention is not limited to the specific form illustrated in the drawings, but contemplates cantilever type antennæ in general. There is no special location for the waist of the antenna; its location is controlled by the special circumstances of each case. If desired, the horizontal cross-section of the antenna could be made circular or some shape other than polygonal, by employing curved interconnecting members between the uprights.

It may be desirable to employ a more highly conducting material than ordinary steel; in which case there may be applied a coating of a material such as copper, tin or zinc, which will serve to prevent rusting as well as to improve the conductivity.

What is claimed is:

1. A wave antenna comprising a rigid vertical tower provided with substantially a single principal support at the base, and secondary supporting means applied at one other elevation only, which elevation is intermediate the ends of said tower, whereby said tower is supported as a cantilever, said tower being electrically insulated from ground, whereby said tower alone functions as an antenna.

2. A wave antenna comprising a rigid tower of cantilever design, primary supporting means and secondary supporting means, the base of said tower being attached to said primary supporting means and intermediate points of said tower being attached to said secondary supporting means, said intermediate points lying substantially in one plane which is substantially perpendicular to the longitudinal axis of said tower, said base and

said intermediate points being the only places of support, said tower being insulated from said supporting means, whereby said tower is adapted to alone act as a radiator of radio waves.

3. A wave antenna arrangement comprising a cantilever tower, primary supporting means and secondary supporting means, said supporting means comprising electrical insulators, the base of said tower being attached to said primary supporting means and an intermediate elevation of said tower being attached to said secondary supporting means, said tower tapering to succeedingly smaller cross sections above and below the elevation of said secondary supporting means.

4. A wave antenna for radiating electromagnetic waves comprising a tower having a base portion and a waist portion, said tower resting on said base and tapering to succeedingly smaller cross-sections from said waist to said base, and being supported only at said base and approximately at said waist, the longitudinal extent of said waist portion being relatively small in comparison with the total length of said tower.

5. A wave antenna comprising a metallic tower having a base portion, a waist portion and a top portion, and resting on said base portion, said tower tapering to succeedingly smaller cross-sections from said waist to said base and from said waist to said top, said tower being supported only at said base and approximately at said waist.

6. A wave antenna according to claim 5 in which the height of said tower is more than twenty times its waist.

7. A rigid wave antenna tower comprising a plurality of upright members interconnected by rigid structural members, said upright members tapering toward each other to a virtual point at the base, said tower being supported at the base and at one other place only, which place is intermediate the ends of said tower, said tower being insulated from ground whereby it is adapted to radiate radio waves, said tower being a single continuous electrical conductor.

8. A wave antenna comprising a rigid vertical tower which is effectively a single vertical electrical conductor, said tower being primarily supported at the base and secondarily supported at one other elevation only, which elevation is intermediate the ends of said tower, said secondary supports being guy wires in tension.

9. A wave antenna comprising a rigid vertical tower which is effectively a single electrical conductor of low resistivity insulated from ground, said tower being primarily supported at the base and secondarily supported at one other portion only, said secondary supports being rigid members.

10. A wave antenna according to claim 9 in which said rigid members are connected to said tower by insulators.

11. A rigid tower of total length suitable to act as an antenna for radio broadcasting, comprising a plurality of upright members said upright members being composed of lengths of structural metal joined together, and means for effecting good electrical contact at said joints, said antenna resting on substantially a point support at the base and being secondarily supported at one other portion only, and means at said supports for insulating said tower to enable it to act as a radiator of electromagnetic waves.

12. An adjustable wave antenna comprising a vertical electrically conducting cantilever tower, an electrically conducting pole, and means for holding said pole in a vertical position and in electrical contact with said tower, said holding means being located at the top of said tower and being adapted to allow said pole to be moved in a vertical direction, said antenna being insulated from the ground.

13. A wave antenna comprising a metallic tower, a metallic pole, means at the top of said tower for holding said pole in a vertical position and in electrical contact with said tower, means for supporting said tower at its base and at only one other portion, means for insulating said antenna from ground, and means associated with said holding means for enabling said pole to be moved vertically with respect to said tower, whereby the effective height of said antenna may be adjusted to the height required for maximum radiation of the wave impressed thereon.

14. A wave antenna comprising a vertical tower primarily supported at the base and secondarily supported at one other portion only, said secondary supports being rigid members attached to said tower at points not greater than one-fourth the distance from the base to the top, said tower being insulated from ground.

15. A wave antenna composed of a cantilever tower, primary supporting means and secondary supporting means, said supporting means comprising electrical insulators, the base of said tower being attached to said primary supporting means, and an intermediate elevation of said tower being attached to said secondary supporting means, the length of said antenna tower being approximately equal to one-half the length of the signal wave impressed thereon.

16. A wave antenna comprising a single rigid mast supported as a cantilever by means of a single primary support at its base and secondary supports at a single elevation part way up the mast, each of said supports being provided with insulating

members whereby the mast itself is completely insulated from ground and is adapted for use as a vertical oscillating electric circuit throughout its entire length.

In testimony whereof we affix our signatures.

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